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# Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

The Inboard Motor Boat Engine

PUBLISHED BY

THE TEXAS COMPANY

TEXACO PETROLEUM PRODUCTS

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*Change of Address:* In reporting change of address kindly give both old and new addresses.




# The Inboard Motor Boat Engine

DEPENDABLE and economical operation of the motor boat engine is based upon effective lubrication. Obviously it is the objective of every thoughtful motor boat enthusiast, for it is the basis of minimum fuel consumption and reduced frictional resistance, to the end that maximum duty and power output will be obtained at the lowest expense for maintenance and repair.

Effective lubrication has progressed beyond the stage of an ideal. The combined research efforts of engine builders and the petroleum industry have proved the practicability of designing a compact internal combustion type of power plant which can be so positively lubricated by properly refined oils as virtually completely to remove any element of doubt from the mind of the most inexperienced operator. Given a reputable engine, a lubricating oil refined to meet temperature requirements, and a sea-worthy hull, you can rest assured that you can cover any distance within the fuel storage capacity, on a schedule comparable with modern motor travel, and with an added advantage—freedom from stop lights and traffic jams.

## THE POWER PLANT

The modern motor boat power plant comprises an internal combustion engine of the two or four stroke cycle type, designed to burn gasoline as fuel. It is quite similar to the automobile engine, in fact, certain types are interchangeable with but minor alterations.

On the other hand, where higher powered types of engines are required, in view of the fact that they must normally operate at practically full speed and full power output, bearings, crankcase construction, water jackets, etc., must be somewhat larger and of more sturdy construction than would normally be required in a strictly automotive type of engine. With such heavier duty engines one must also remember that many will be operated in salt water. Precautions must, therefore, be taken to choose materials which will withstand corrosion and any electrolytic action which might be caused where salt water is used as a coolant.

Operating requirements in many motor boat engines will differ from automotive practice in that air cooling will normally be restricted, resulting frequently in higher engine temperatures. In the average engine block temperatures will be lower; crankcase temperatures, however, will be higher, due to lack of air circulation.

For inboard service, the four-cycle engine is chiefly used. For the information of the layman, the four stroke cycle principle requires four strokes of each piston from one end of the cylinder to the other for the complete combustion of a charge of fuel. Dependent on the size and power requirements, either four, six, eight or twelve cylinders are used. In order to understand clearly what takes place as the engine operates, it is advisable to discuss this matter of the operating cycle step by step.

The four successive stages or strokes involved are:

The intake stroke
The compression stroke
The power stroke, and
The exhaust stroke.

## The Intake Stroke

This is virtually the commencement of the cycle; at the beginning of the stroke provision is made for the admission of the requisite mixture of gasoline vapor and air via the carburetor, as the piston moves downward in a manner similar to that in which a pump is filled with water. During the major portion of this stroke the inlet valve is open and the exhaust valve closed.

A partial vacuum is created during this stroke. As the piston moves down the fuel charge is drawn into the cylinder through the carburetor. At the same time a certain amount of lubricating oil on the cylinder walls will work up past the piston rings into the compression chamber, unless this oil is sufficiently viscous to adhere properly to the cylinder walls.

The amount of lubricating oil which may pass the piston rings and work up into the explosion chamber during the intake stroke will vary according to the fit of the rings in the cylinder and the viscosity of the oil. These same conditions, that is, the fit of the piston rings and the viscosity of the lubricating oil, also affect the degree of compression, which can be secured and maintained during the next stroke.

## The Compression Stroke

At the beginning of this stroke the piston is at the bottom of its travel and is ready to move upward. Both valves are closed during the major portion of this stroke, which is an extremely important phase of the cycle in the operation of the engine, as far as the production of power and the general economy are concerned. As the piston travels upward it compresses the air and gas mixture in the cylinder above, the degree of compression being dependent largely upon:

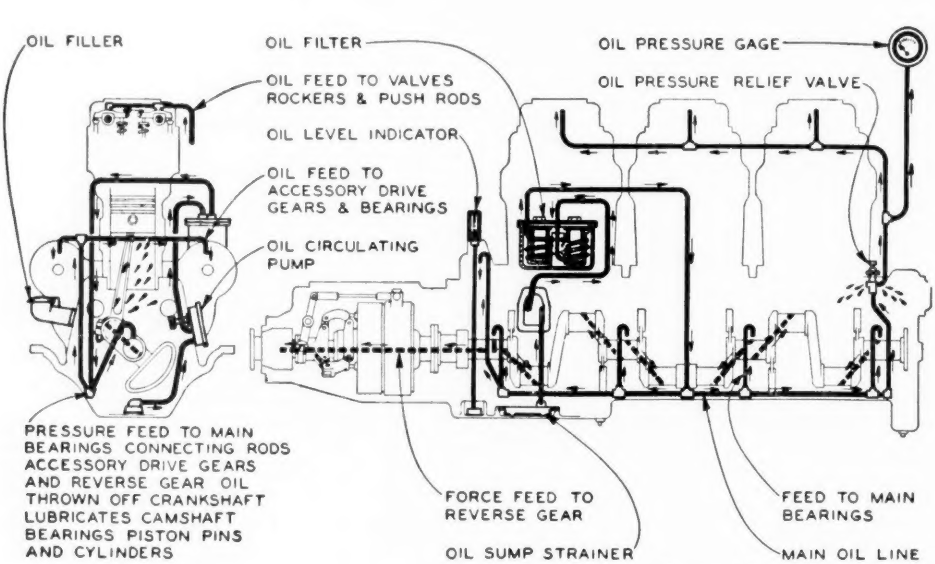
The closeness of fit between the piston, its rings, and the cylinder walls.
The flexibility of the rings, and
The extent to which the oil maintains a seal between the cylinder walls and the piston rings.

Inasmuch as the cylinder is closed, any loss of compression will probably be due to:

Improper seating of the valves
Poor mechanical fit of the piston rings, or
Ineffectual lubrication.

The lubricating oil may be indirectly the cause of poor mechanical fit of the valves and piston rings on account of hard carbon being deposited to interfere with their action.

Insufficient lubrication, even with a good oil, will ultimately result in loss of compression,




*Courtesy of Sterling Engine Company*

Fig. 1—Lubricating details of the Sterling Dolphin marine engine. Oil is delivered by pressure pump through the oil filter and cooler to main oil line and thence to main bearings, connecting rods, timing gears and other moving parts. Cylinder walls, camshaft bearings and piston pin bearings are lubricated by oil thrown from connecting rods.

irrespective of the original mechanical fit of the piston rings. With good lubrication, on the other hand, and use of an oil of the right characteristics, compression can be reasonably maintained, even with slightly worn rings.

### The Power Stroke

At the beginning of this stroke the piston is at the topmost point of its travel. It is, therefore, in position to do work as it is forced down by the explosion and subsequent expansion of the gaseous mixture, which has been compressed to approximately 100 pounds per square inch. As in the compression stroke, the inlet and exhaust valves are closed during the greater part of this stroke. The explosion of the mixture and the resultant expansion of the gases produces the power to drive the engine. Provided the carburetor is properly adjusted so that the mixture is in the right proportion for effective work, the amount of power developed from the explosion is largely dependent upon the compression secured during the second stroke; the greater this compression the higher will be the initial pressure at the time of the explosion, and consequently the greater the force of explosion.

If the seal between the piston rings and cylinder walls is effectively maintained by the lubricating oil and the mechanical fit of the piston rings, the mixture during the second stroke will be compressed to a higher degree. At the same time, during the explosion or power stroke less of the force which should be expended in driving the piston down should be lost through leakage or blow-by past the piston rings.

### The Exhaust Stroke

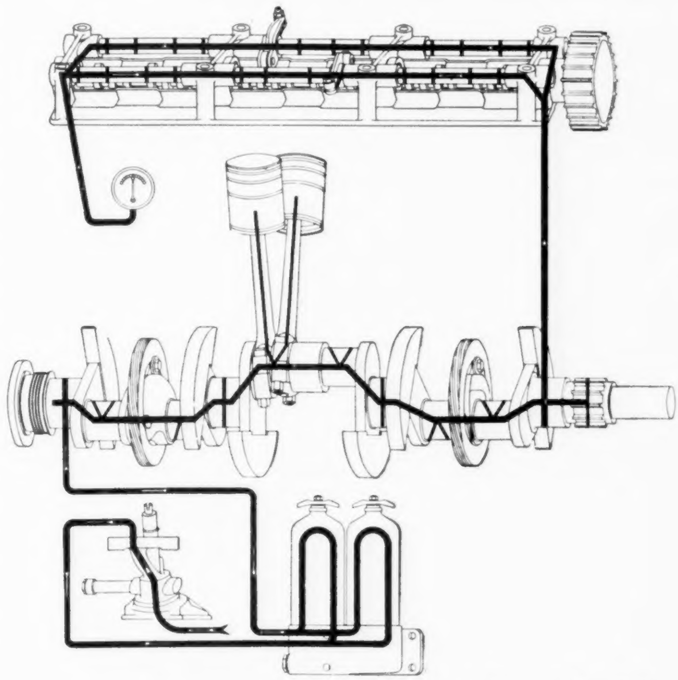
During this stroke the exhaust valve is open; the inlet valve is closed to enable the piston to force the waste gases out of the cylinder on its upward travel.

This stroke completes the fourth movement of the cycle, during which two revolutions of the crankshaft are required.

## POWER DEVELOPMENT

In addition to the efficiency of the carburetor in bringing about mixture of gas and air, the total power developed by the motor boat engine is dependent upon compression. The less power required to overcome friction developed by the moving parts of the engine, the more power will be available to drive the propeller. Friction and power losses can be materially reduced by effective lubrication.

The troubles attendant upon poor compression in the engine cylinders are well known to most motor boat owners. They should also be conversant with the fact that properly installed piston rings of suitable design, which fit properly with respect to the cylinder walls, are absolutely essential to original development of adequate compression, maintenance of which can be accomplished by use of a lubricating oil of such a viscosity that the clearance space between the piston rings and cylinder walls will be entirely and continually filled by a lubricating film of adequate body.



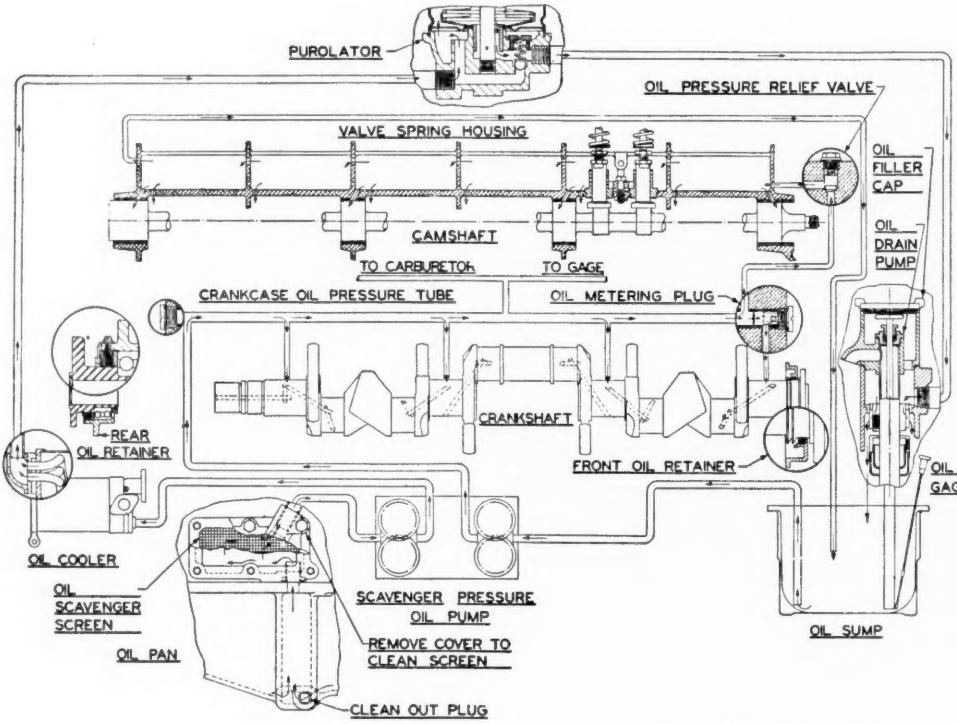
*Courtesy of American-LaFrance and Foamite Corp.*

Fig. 2—Lubricating diagram of the American-LaFrance V-12 marine engine. This is a completely self-contained and self-regulated system with full force feed distribution of oil throughout the engine.

## SELECTION OF LUBRICANTS

As a result, the selection of marine motor oil for any type of motor boat engine is a most important matter if economy and maximum power are to be obtained. By reason of the usual size and power capabilities of such engines, it is sometimes best to use a somewhat heavier or more viscous lubricant than would generally be necessary for the average automotive engine, especially since they will run at maximum power output, and normally at top speed.

The danger of using an oil of too heavy a viscosity should not be overlooked. This might lead to abnormal internal friction within the engine and decrease in power available to the propeller shaft. In this regard, the efficiency of the cooling system should be studied. In a new engine there is often possibility of over-cooling. Under such conditions, where the engine is tight throughout, running at reduced temperatures with an oil of too high a viscosity may lead to serious difficulty. The efficiency of any marine cooling system will, however, decrease comparatively rapidly, especially in salt or hard water service.




*Courtesy of Scripps Motor Company*

Fig. 3—Oiling diagram of a Scripps marine engine, with essential details clearly indicated. Note that cylinder walls, pistons and piston pins are lubricated by excess oil thrown off by the crank pins.

The lubricating system must, of course, be taken into account, for this will likewise be a factor in deciding upon the viscosity of the oil. For example, where full pressure lubrication is employed via the medium of holes drilled in the crankshaft and rods, an oil of higher viscosity can be used, due to the fact that the bearings will normally be continually flooded with oil at a pressure commensurate with the operating speed of the engine. Frequently this affords better sealing of the pistons and reduces compression losses or blow-by, especially where an excess of dilution may tend to occur, due either to engine construction, wear, careless operation, the use of too rich a mixture, or two frequent use of the choke.

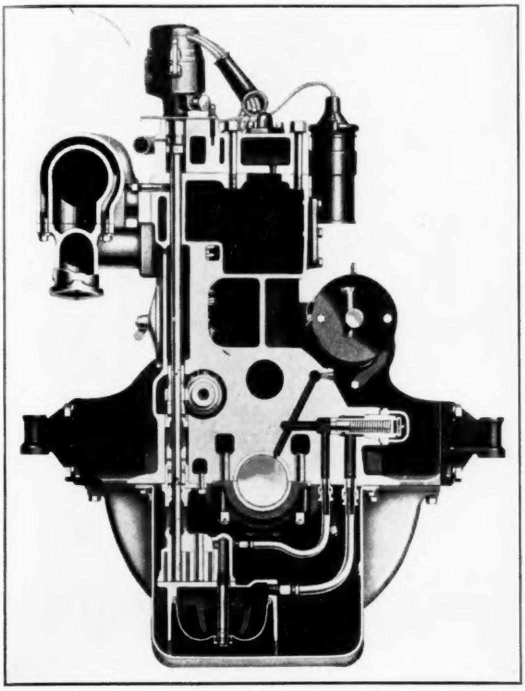
Proper circulation of oil is assured by the use of two oil pumps in certain types of engines which must be installed with the center line of the crankshaft in an angular position. In such engines the pressure pump serves to circulate the oil through the lubricating system, the scavenger pump taking up the oil from the low point of the engine and returning it to a sump in which is located the suction for the pressure pump.

Where the lubricating system involves the distribution of the oil by spray to a more or less extent, the oil must naturally be of such a viscosity or degree of fluidity as to permit of ready and complete distribution to all the wearing surfaces. One must not overlook the fact, however, that a certain amount of dilution or thinning out of the lubricating oil by unburned fuel will probably always occur in any engine. This automatically brings about a reduction in viscosity. Furthermore, it takes place within a very short period of time after a charge of new oil is introduced and worked in the engine. Therefore, it will be advisable to keep this fact in mind when buying new oil.

## Starting Procedure.

In subsequent operation the operator should use every care to avoid:

1. Starting with the throttle wide open, and
2. Flooding the carburetor to excess.



*Courtesy of Chrysler Motors—Amplex Division*

Fig. 4—Cross-section showing drilled passages, oil pump and relief valve in a Chrysler marine engine.

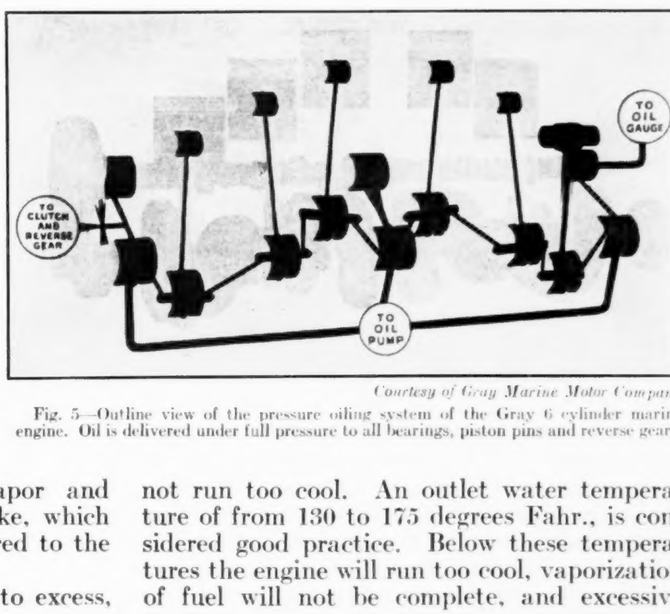
This matter of flooding or the use of an excessively rich mixture is so important to every motor boat owner as to warrant a somewhat more detailed discussion to bring out the relationship it bears to dilution. In the opinion of automotive experts today, it is generally agreed that in the summer, or even in winter when the engine is running under normal temperature conditions, there is no difficulty experienced with modern gasoline. Under relatively cold cylinder water jacket conditions, however, especially when starting, the amount of gasoline which will vaporize without external heat is considerably less than in warm weather or when the engine is hot. As carburetors are adjusted for the heated conditions, in order to obtain the proper mixture of vapor and air, it is customary to use the choke, which cuts down the amount of air delivered to the mixture on starting.

The choke should never be used to excess, however, otherwise a considerable amount of the fuel may remain in liquid state, probably to leak past the piston rings, wash the film of lubricating oil from the cylinder walls, and work into the crankcase, where dilution of the lubricating oil will result. If this is allowed to continue, other detrimental features will be:

1. A tendency of the engine to overheat, and
2. Excessive formation of carbon.

It is evident that continued use of the choke to produce a relatively uniform flow of rich mixture to the engine, especially when warming up, would bring about the same objectionable results; therefore, in using the choke, it should be pulled all the way back until one or two explosions have taken place. Then it should be pushed in and the engine kept running by intelligent handling of the throttle, until warming up is completed. This process should never be hastened. Unfortunately, use of the choke is a necessary evil in practically every instance of cold starting and yet the operator should resort to this as little as possible, if he has the welfare of his engine at heart. Furthermore, the engine should never be run at more than moderate speed until the lubricating oil has had time to be worked up onto the cylinder walls and replace that which has been washed off by the liquid fuel referred to above.

Normally incomplete vaporization will be liable to occur only during the period of warming up if proper provision is made to keep the cooling water in the cylinder jackets at a sufficient temperature to insure that the engine will not run too cool. An outlet water temperature of from 130 to 175 degrees Fahr., is considered good practice. Below these temperatures the engine will run too cool, vaporization of fuel will not be complete, and excessive



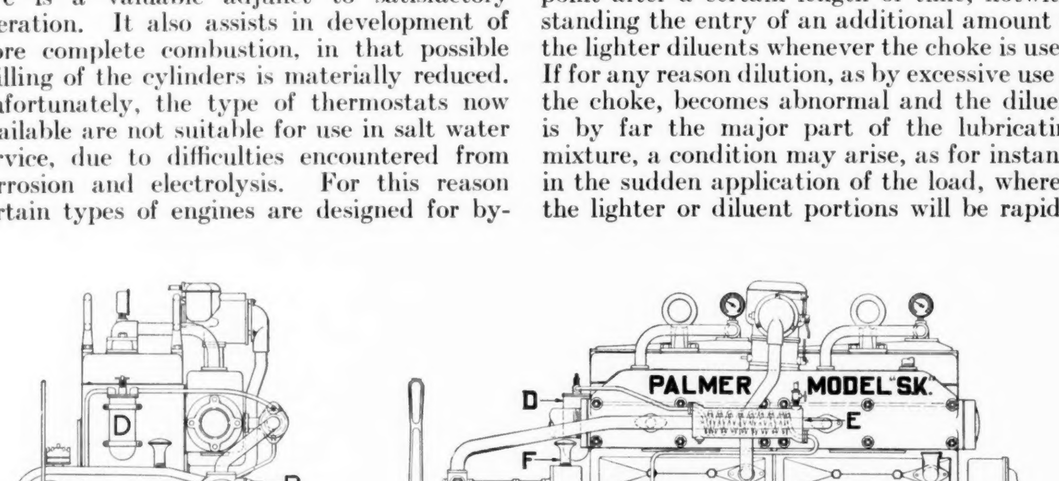

*Courtesy of Gray Marine Motor Company*

Fig. 5—Outline view of the pressure oiling system of the Gray 6 cylinder marine engine. Oil is delivered under full pressure to all bearings, piston pins and reverse gears

dilution of crankcase oil will occur, as explained above, during the entire period of operation. A thermostat to control the engine temperature is a valuable adjunct to satisfactory operation. It also assists in development of more complete combustion, in that possible chilling of the cylinders is materially reduced. Unfortunately, the type of thermostats now available are not suitable for use in salt water service, due to difficulties encountered from corrosion and electrolysis. For this reason certain types of engines are designed for by-

impaired, with consequent loss in compression.

In the average running of the engine, crankcase dilution apparently reaches an equilibrium point after a certain length of time, notwithstanding the entry of an additional amount of the lighter diluents whenever the choke is used. If for any reason dilution, as by excessive use of the choke, becomes abnormal and the diluent is by far the major part of the lubricating mixture, a condition may arise, as for instance in the sudden application of the load, wherein the lighter or diluent portions will be rapidly




*Courtesy of Palmer Brothers Engines, Inc.*

Fig. 6—Showing the Palmer marine engine. A indicates oil pump of the Evans sliding vane type, C the oil sump, D oil filter of the Pur-O-later type, E the oil cooler, F the crankcase breather, G oil strainer in sump, H a union to facilitate removal of strainer, I the carbon retaining screen to prevent carbon from passing to the oil sump, M fuel pump of the Evans type, P the water pump regulator.

pass or re-circulation of cooling water through the engine, to increase the temperature.

## Crankcase Dilution

There is considerable difference in opinion as to the actual harmful effects that may accrue to bearing lubrication from crankcase dilution. This subject has been extensively discussed among internal combustion engine authorities, to the end that it is generally agreed that crankcase dilution does occur at practically all times, and especially rapidly under colder engine temperatures. It is doubtful, however, whether it is worthy of all the attention it has received. Certainly it has often been treated in a rather biased manner and many statements have been made that are chiefly suppositions.

From a lubrication viewpoint there is relatively little danger of bearings actually being burned out simply because the lubricant is reduced in viscosity by ordinary fuel dilution, although a lighter lubricant will splash more freely and there will be greater possibility of pumping occurring, which may result in excess carbonization and the piston seal becoming

evaporated from the film on the cylinder walls because of rapid heating of the cylinders. In such a case the lubricating film may be reduced sufficiently in thickness so that scored cylinders will be possible.

Experiments have shown that while the state of equilibrium between any lubricating oil and the lighter fuel portions will vary with the nature of the constituents, it will balance itself of its own accord if sufficient time is allowed. If an equilibrium condition of 20 per cent diluent was normal, if 40 per cent diluent were started with in the crankcase the lubricating mixture would tend to return to its state of equilibrium.

## HOW WATER AND SLUDGE MAY AFFECT OPERATION

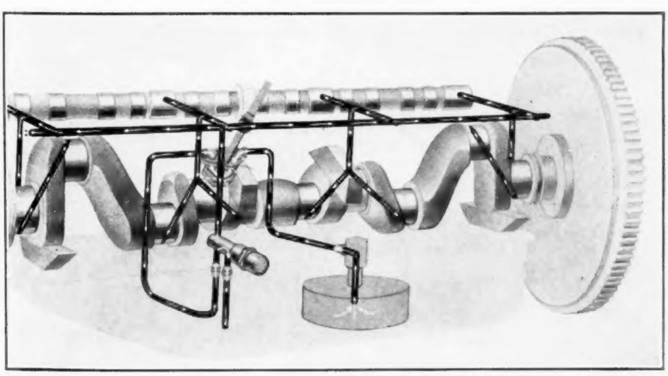
Water in the crankcase or oil sump of a marine engine will be conducive to rust, ice, emulsification and sludge formation. This will be especially true in cold weather or where dust, dirt, carbon or metallic particles have been allowed to accumulate to any extent. The oil filter and air filter are of course effec-

tive in reducing such accumulations. They should never be regarded, however, as so positive as to insure complete removal of non-lubricating foreign matter. For this reason, periodic changing of oil in accordance with manufacturer's recommendations and careful flushing of the crankcase and lubricating system will be most advisable in the interests of prolonging the life of bearings and piston rings, the prevention of undue wear on cylinder walls, and the assurance of more dependable operation.

## Water Developed During Combustion

Just how water may gain entry into such a carefully built and enclosed machine as a marine engine will be of interest. The possibility of entry from an external source is remote, provided reputable gasoline and lubricating oil are used which can be depended upon to be water-free. Far more frequently will it be developed within the engine itself, as a product of combustion or condensation.

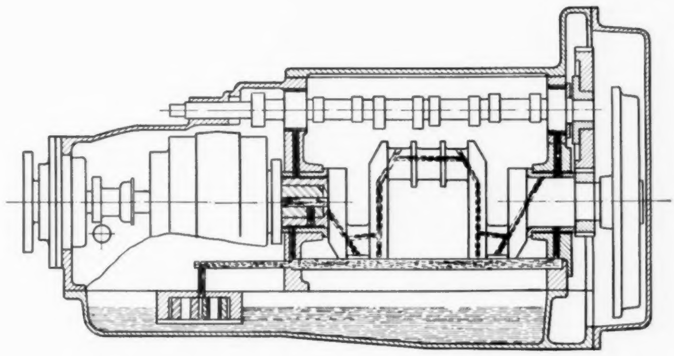
The condition of the engine will of course influence the degree to which such water may find its way into the lubricating system. In other words, where piston rings are worn or cylinder walls scored or abraded to result in abnormal clearance, an effective seal cannot be as readily maintained by the lubricating oil as in an engine where the proper fit exists between the pistons and cylinder walls. High or uneven clearances will be conducive to leakage of water vapor past the piston rings and into the crankcase. In cold weather, and especially on starting, water-contamination of the lubricating oil may increase very rapidly. For this reason oils should be changed more frequently in winter than in summer, just as is recommended in automotive practice.



*Courtesy of Chrysler Motors-Amplex Division*

Fig. 7—Showing method whereby oil is passed through drilled passages to all main bearings, crank pin bearings and camshaft bearings on a Chrysler marine engine.

Experience has shown that more water vapor is developed in the process of combustion than there is fuel consumed. How much of this will ultimately reach the crankcase to mix with the oil therein as actual water will, of course, depend on how effectively the piston rings and lubricating film function in the maintenance of a suitable seal.



*Courtesy of Gifford-Wood Company*

Fig. 8—Lubricating system of the Gifford-Wood Midshipman II marine engine. Main and camshaft bearings and reverse gears are pressure lubricated. Pistons are lubricated by oil spray from the crankshaft.

## Crankcase Condensation Also May Develop Water

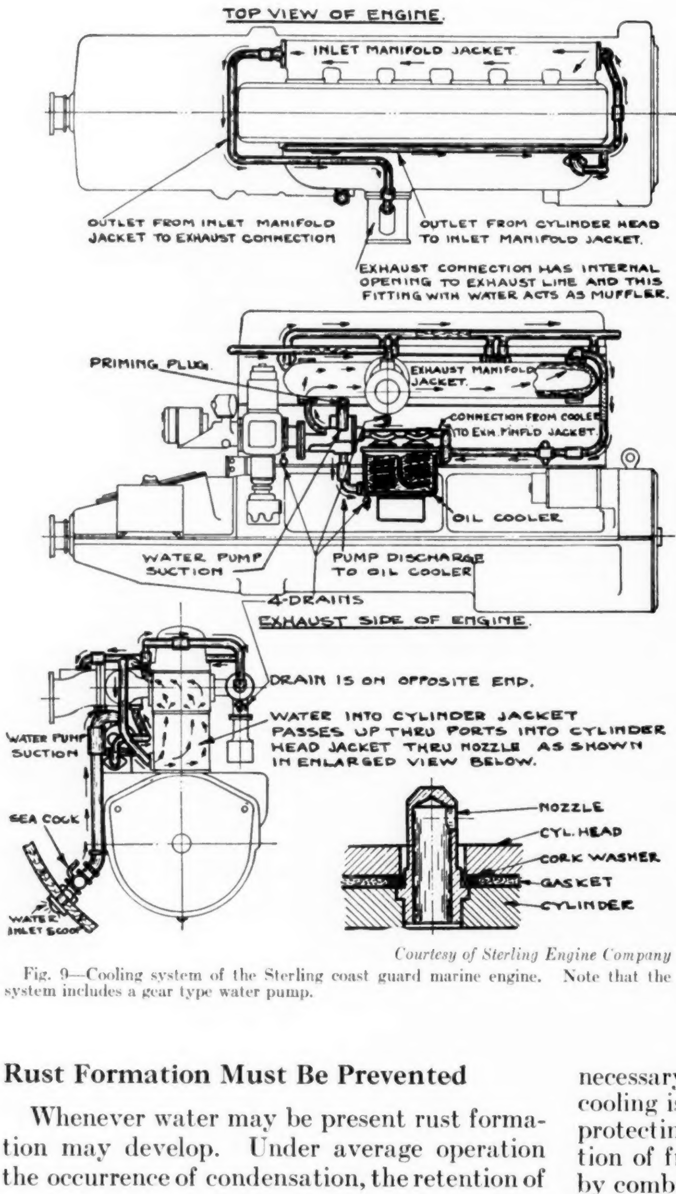
Water, of course, may also be condensed from the air within the crankcase, for under normal conditions of design air has full access through the crankcase breather. Here again the variables involved will preclude even an approximate estimate of how much water to ultimately expect. It will depend upon the moisture content of the air, the weather, the atmospheric temperature, the frequency of starting and stopping and the extent to which the engine actually becomes properly heated. In salt water service, condensation of salt air may present an added impurity in the form of actual salt accumulations.

## Separation of Water in the Oiling System

Unless a device specifically designed for removal of water from the oil in service is installed, emulsification and sludge formation can be the normal expectation. But these developments will, of course, not occur as rapidly with new or comparatively fresh oil as later on when the oil has been in service for some time.

Normally the extent to which water will be

held in suspension will depend upon the degree of contamination of the oil from other sources. The greater the purity the more readily will emulsions be dissipated and water precipitated to the bottom of the crankcase or oil sump.




*Courtesy of Sterling Engine Company*

Fig. 9—Cooling system of the Sterling coast guard marine engine. Note that the system includes a gear type water pump.

### Rust Formation Must Be Prevented

Whenever water may be present rust formation may develop. Under average operation the occurrence of condensation, the retention of a certain amount of water in the engine, and its ultimate presence on the cylinder walls and in the crankcase oil will be prevalent. Obviously rust formation must therefore be considered, especially where the engine is allowed to stand cold for any length of time. Research has indicated, however, that if provision is made to maintain the temperature of the engine cooling water sufficiently high (i.e., in the neighborhood of 150 to 180 degrees Fahr.), this possibility of rusting will be decidedly reduced, a considerable part of any water formed being passed off via the crankcase breather. In addition, if provision is made to circulate an abundant supply of highly refined lubricating oil to all moving parts of the engine, the possibility of rusting during stand-by will be materially reduced.

## BEARING DESIGN

Bearing lubrication requirements as they may apply to the motor boat engine can best be appreciated by an understanding of the principles of plain bearing construction. This type of bearing is most generally applied to the moving parts of such engines, in view of the prevailing stresses due to continued high speed operation and the normally high temperatures. To enable positive maintenance of a continuously protective lubricating film, clearance spaces are comparatively high, according to the size of the respective shafts or pins.

To enable most positive distribution of lubricant, full pressure circulation of oil is extensively employed. This requires use of hollow or drilled crankshafts, connecting rods and piston pins. There is an added advantage to such construction, in that engine weight is reduced, without any material effect upon power output.

### Rate of Oil Circulation

Inasmuch as the lubricating oil in the modern motor boat engine serves a dual purpose, functioning not only as a lubricant, but also as a coolant, a rate of oil circulation is required considerably above that necessary for lubrication alone. Adequate cooling is absolutely essential in the interest of protecting the bearing against undue accumulation of frictional heat plus the heat developed by combustion. The amount of oil that should be circulated per minute will depend upon the type of engine, the method of external cooling and the viscosity of the oil. Such heat as is taken up by the engine oil in circulation is subsequently removed by the oil cooler through which return oil is passed prior to re-circulation. This latter is a very necessary adjunct, since there is but little circulation of air and

therefore but little crankcase radiation.

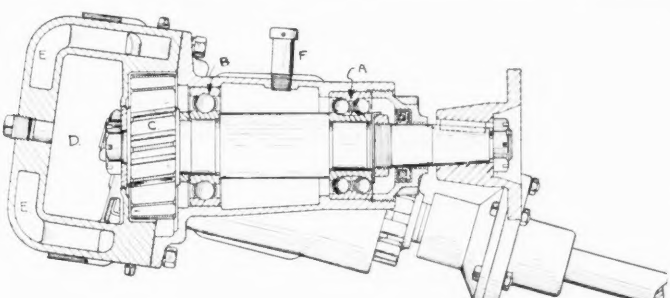
A rate of oil flow of approximately one-half a gallon per horse power per hour has been found to be satisfactory, provided the oil is of such viscosity as to give minimum temperature rise. Should the viscosity be too low it may be incapable of maintaining a protective film of sufficient thickness within the bearing clearances, with the result that more nearly metallic contact will prevail, to cause increased friction with proportional rise in temperature. The possibility of this becoming cumulative and causing absolute bearing failure must always be given careful consideration. Fortunately, bearing design and lubricating oil viscosities have been studied so intensively as to prevent such an occurrence, provided oils of reputable manufacture especially refined for marine service, are used.

## Design and Oil Pressure

Plain bearing construction will differ from similar bearings used in certain other types of machinery, in that as a rule there will be fewer grooves cut, or frequently none at all. In part, the reason for this is to avoid decreasing bearing area to any marked degree. Removal of bearing metal to form a path for oil to follow may also interfere with the formation of the lubricating film.

Furthermore, where bearings are pressure lubricated there will not be the same need for oil grooves, for distribution will be properly maintained by the prevailing oil pressure. This can be varied according to the working pressures expected.

Oil pressure will vary automatically with

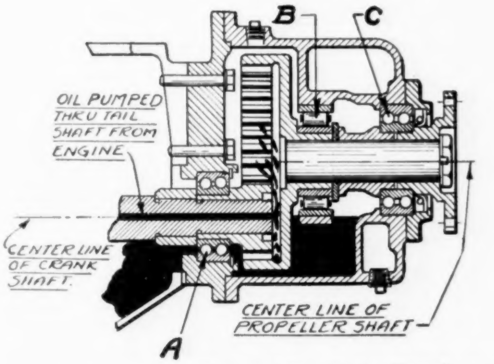



*Courtesy of Gray Marine Motor Company*

Fig. 10—Showing the Gray "Vee-Drive" gear: A indicates double row, over-size ball thrust bearing on each shaft; B the heavy duty ball carrier bearing; C special ground hyperboloid gears; D oil reservoir with water-cooled walls; E water jackets, and F the breather tube.

bearing temperatures. For example, it will be comparatively high when cold starting. As the engine bearings warm up, however, the viscosity or body of the oil will be reduced, facilitating more ready flow through the clearance spaces.

The cause of oil pressure drop with rise in temperature has been the subject of certain studies which have indicated that there is agreement with certain of the laws of flow of oil through pipes, to the extent that the amount of oil passing through a lubricating system is




*Courtesy of Gray Marine Motor Company*

Fig. 11—Details of the Gray reduction gear unit with provisions for full pressure lubrication from the engine oiling system. A is the pilot bearing, B roller bearing, C a double row ball thrust bearing.

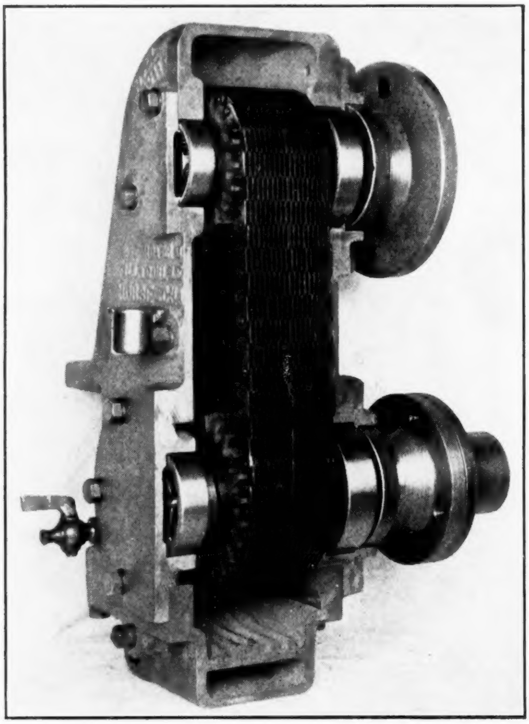
proportional to the pressure, provided the viscosity is constant; or conversely, if the pressure is constant the amount of oil passing through the system will decrease rapidly with increase in viscosity or decrease in temperature.

Study of the flow of oil through pipes indicates that there are two types of flow; i.e., viscous or stream line flow and turbulent flow. In the case of viscous or stream line flow the pressure drops directly with the viscosity. In turbulent flow, however, a 50 per cent drop in viscosity may only bring about a 10 per cent drop in pressure. In a typical motor boat engine lubricating system there will probably be a combination of these two types of flow.

It is important to remember that the above applies to lubricating systems where there is no change in the cross section area of the oil passage and where there is no back slip of oil through the pump, as, on account of changes in bearing clearances, due to temperature fluctuation, the oil may by-pass into the crankcase without going completely through the system, pressure will tend to drop if there is any slip in the pump, when the oil becomes hot.

One should never regard the oil pressure alone as indication that the engine is receiving lubrication unless that pressure is below the setting of the relief valve. For instance, if an engine shows 50 pounds continually, 90 per cent of the oil may be going out through the

by-pass and only 10 per cent through the engine. This certainly would not give sufficient lubrication. The higher the viscosity of the oil, the less will go through the engine with the



*Courtesy of Morse Chain Company*

Fig. 12—Sectional view of the Morse transfer drive as designed for motor boat service. Note oil filler, oil level cock and oil drain plug at left hand side of the case. Oil sump is located below the chain with the cooling water jacket at the base.

same relief valve setting, as more will go through the by-pass. Some manufacturers are coming to realize this situation and are calling for a lighter oil to be used in their engines in order to give better assurance of lubrication.

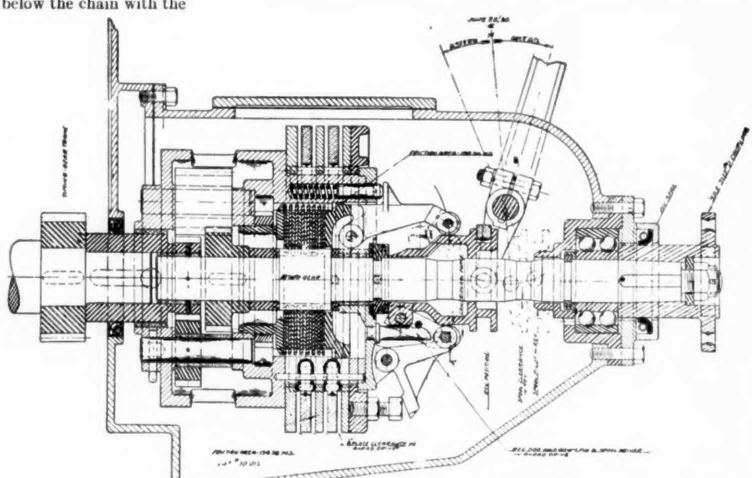
Oil filters should be inspected regularly to prevent recirculation of dirty oil through the filter bypass unit. In some engines a gauge is installed on the filter inlet and outlet, the manufacturers recommending that the filter be inspected when a pressure difference develops in excess of ten pounds.

## PISTON RINGS, COMPRESSION AND LUBRICATION

Piston rings enable maintenance of compression, economy of lubricant and serve as insurance against abnormal formation of carbon deposits in the combustion chamber, by preventing passage of excessive lubricating oil into this space. When capable of functioning properly piston rings also conduct a certain amount of heat away from the combustion chamber to the cylinder walls, from which this heat is in turn transmitted to the cooling system.

Compression is absolutely necessary if an engine is to develop its intended power. Obviously should loss of compression occur, blow-by of the combustible fuel gases would result. Also, after explosion, this working of hot gases from the combustion chamber past a set of ineffectual rings would destroy the protecting lubricating film, and lead to actual contact between the rings and cylinder walls. The resultant friction would cause wear, over-heating and progressive increase in the amount of compression lost, until finally the engine would be operating in such an inefficient manner as to require extensive repair.

These detriments of blow-by must be thoroughly understood with regard to the motor boat engine, for it becomes more prevalent with increase in engine speeds, the gases of combustion tending to work past certain types of rings at the outside diameter adjacent to the joint. Where an engine operates under continued high speed such leakage may become a most serious matter. In full appreciation of this fact, manufacturers of piston rings have carefully studied existing conditions, in order



*Courtesy of Palmer Brothers Engine, Inc.*

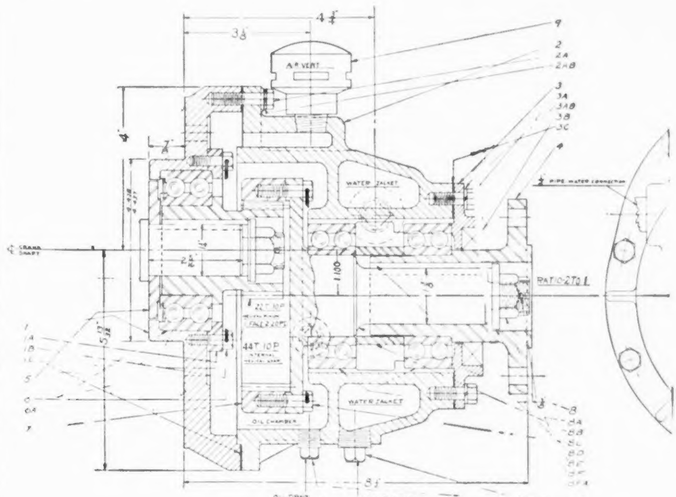
Fig. 13—Sectional view of the Palmer reverse gear, equipped with reversing plates, gear teeth are ground to eliminate noise and drag. Norma-Hoffmann bearings and Chicago Rawhide seals are employed to increase efficiency and prevent leakage of lubricant. Manufacturers recommend a comparatively light oil in order to reduce foaming.

to design their rings to have sufficient additional strength and pressure at the joints to withstand effectively any passage of hot gases from the combustion chamber into the crank-case.

Where the rings and piston are perfectly concentric with respect to the cylinder bore and capable of exerting uniform radial pressure over their entire sliding surface at the operating temperatures, control of cylinder lubrication by even distribution of oil over the cylinder walls can be most readily maintained. A properly functioning ring will press the oil film tightly and evenly against the cylinder wall and markedly reduce the possibility of oil pumping or passage of oil into the combustion chamber. Rings of adequate tension also strengthen the oil film and render it more resistant to being blown out from between the rings and cylinder walls, especially during the high pressure stages of the operating cycle.

## Carbon Accumulation

The motor boat operator is fortunate in that he need not worry about fuel analysis and the presence of solid or abrasive foreign matter which contribute to ring wear. He must, however, be concerned about incomplete combustion and the possibility of resultant carbon accumulations around the piston rings. Obviously this would affect the free motion of the rings in their respective piston grooves, frequently to such an extent as to lead to commencement of the objectionable cycle of loss in compression, blow-by, reduced lubrication and wear. Proper

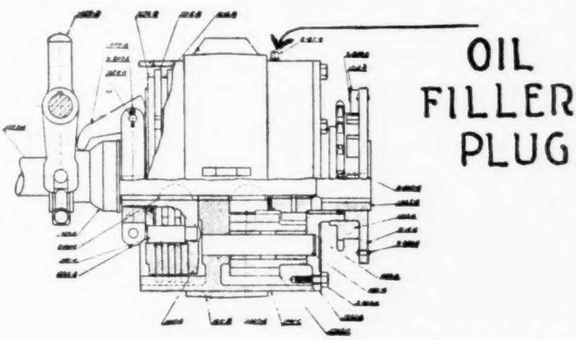


*Courtesy of Snow and Petrelli Mfg. Co.*

Fig. 14—Sectional view of Joes reduction gear. This unit is built in 2 types, one water cooled with a separate oil chamber; the other oil cooled and lubricated by force feed from the engine.

carburetion will, of course, assure of satisfactory combustion, provided the choke is not used to an excess.

Use of an unsuitable lubricating oil, that is, one which shows comparatively high carbon residue by the Conradson laboratory test, is more frequently the cause of carbon accumulations around the piston rings, and their resultant sluggish action. The oil film at the top of the cylinder walls is naturally exposed to the highest engine temperatures, but only for a comparatively short time during each cycle,




*Courtesy of Brennan Motor Manufacturing Co.*

Fig. 15—Showing the Brennan clutch and reverse gear assembly with provisions for lubrication.

for as the working stroke occurs the cylinder wall temperatures drop rapidly and yet a certain amount of the oil is burned at each firing stroke.

Where such carbon is light and non-gummy in nature it naturally will be more rapidly carried out of the engine by the exhaust, to result in better assurance that the piston rings will continue to function freely and unhampered by any accumulation of hard, sticky carbonaceous matter around or in back of them.

# ACCESSORY EQUIPMENT

Other parts of the motor boat engine which require lubrication will include:

- The water pump
- Reversing and reduction gears
- The thrust and propeller shaft bearings, and
- The bearings of the generator, starting motor and magneto.

With the exception of the bearings of the electrical equipment and the various gear mechanisms, grease lubrication is provided for on the above mentioned parts.

## Water Pump Requirements

Modern engine design has included the plunger, gear or modified type of centrifugal pump, as the most dependable means of circulating cooling water through the engine block and cylinder jackets. Positive displacement pumps are essential to the motor boat engine wherever the suction may come above the water line at any time; also, where

the water may contain sand, grit or dirt, the latter would interfere with operation of a rotary type pump. For this reason the gear or plunger type pump is widely used, although centrifugal pumps are also adaptable where the pump inlet is always below the water line. The lubricating requirements of such pumps are comparatively simple, although considerable difficulty may arise if careful attention is not given to selection of a suitable lubricant. Bearings are normally designed for grease lubrication, compression grease cups being employed for application. It is highly essential that a water pump grease be insoluble in water, and of sufficient body or consistency to form an effective seal against water leakage. This is attained by compounding a comparatively low viscosity mineral oil or high degree of refinement with sufficient lime or calcium soap to produce a relatively inert grease. It may often require considerable pressure on the lubricator to apply such a grease, but this pressure in itself is assurance against subsequent leakage.

It is also practicable to use an automatic type of grease cup which will deliver the lubricant at a uniform rate while the engine is running. Devices of this type assure positive lubrication as long as they are kept properly filled. Certain engine builders have standardized on such equipment in the interest of maximum protection of their water pumps.

## Speed Reduction Mechanisms

Considerable attention has been devoted to studying the adaptability of speed reduction mechanisms to the motor boat power plant, in order to eliminate waste of motor power and speed through improper application to the propeller. Effective application of speed reduction is also regarded as beneficial in extending the advantages of the modern high speed engine to heavier boats which require the use of over-size propellers.

Straight line connections, V-drives or the use of silent chain drives have all been proved to be decidedly practicable. Sponsors of the V-drive and silent chain stress other advantages due to location of the power plant in the stern, viz.:

Availability of more useful space in the center of the boat, and

Lowering of the center of gravity at a point where it is most beneficial in facilitating handling, and speed development.

Gears of the spur or helical type are chiefly used in motor boat installations, the former being applied to straight line reductions. Helical or hyperboloid gears on the other hand have been proved best suited to the V-drive design.

Lubrication of any set of reduction gears can be accomplished by circulation of motor oil under pressure from the engine, or independently from an oil bath in the base of the gear case. This same method of lubrication is applied to silent chain installations.

Where gears are lubricated from the engine oiling system, the same grade of oil is, of course, used throughout. Under such conditions an oil of lighter body or viscosity can be used because it is applied to the contact surfaces of the moving parts under sufficient pressure to withstand at least part of the load. In a bath lubricated system, however, the body of the oil alone must be depended upon to carry the prevailing gear tooth loads and maintain a lubricating film of sufficient strength to resist being squeezed out from between the teeth during operation.

This will require the use of an oil of steam cylinder characteristics. In warm weather operation an oil having a Saybolt viscosity of approximately 140 to 150 seconds at 210 degrees Fahr., will conform to builders recommendations. As one approaches colder weather it will be advisable to consider a certain amount of reduction in the body of the gear lubricant, dependent upon the operating temperatures to be encountered. At the time of change cleaning and flushing of the gear case with kerosene will assure removal of abrasive foreign matter which might otherwise cause wear or scoring of gear teeth or bearings if allowed to contaminate the gear lubricant.

*Advantages of Water Jackets*

The installation of water jackets as integral parts of the housings which surround certain types of speed reduction mechanisms, serve as an adjunct to effective lubrication inasmuch as they enable comparatively accurate control of temperatures and maintenance of lubricant viscosity within a range which will be conducive to minimum drag and power consumption, and maximum protection of the gear tooth or chain surfaces. Water jackets are especially advantageous in cold weather when they can be used for circulation of warm water from the engine around the gear case by suitable arrangement of piping and control valves.

Unfortunately, when starting up an engine in cold weather a considerable period of time may elapse before the water in the cylinder jackets reaches a temperature sufficiently high to be of much value in lowering the viscosity of the oil in the speed reduction case, unless the operator runs the engine long enough to bring up the water jacket temperatures of the speed reduction mechanism before putting the boat in operation. In turn, when the boat is stopped, complete draining of any such cooling system should always be done in cold weather, to insure against freezing and subsequent damage.



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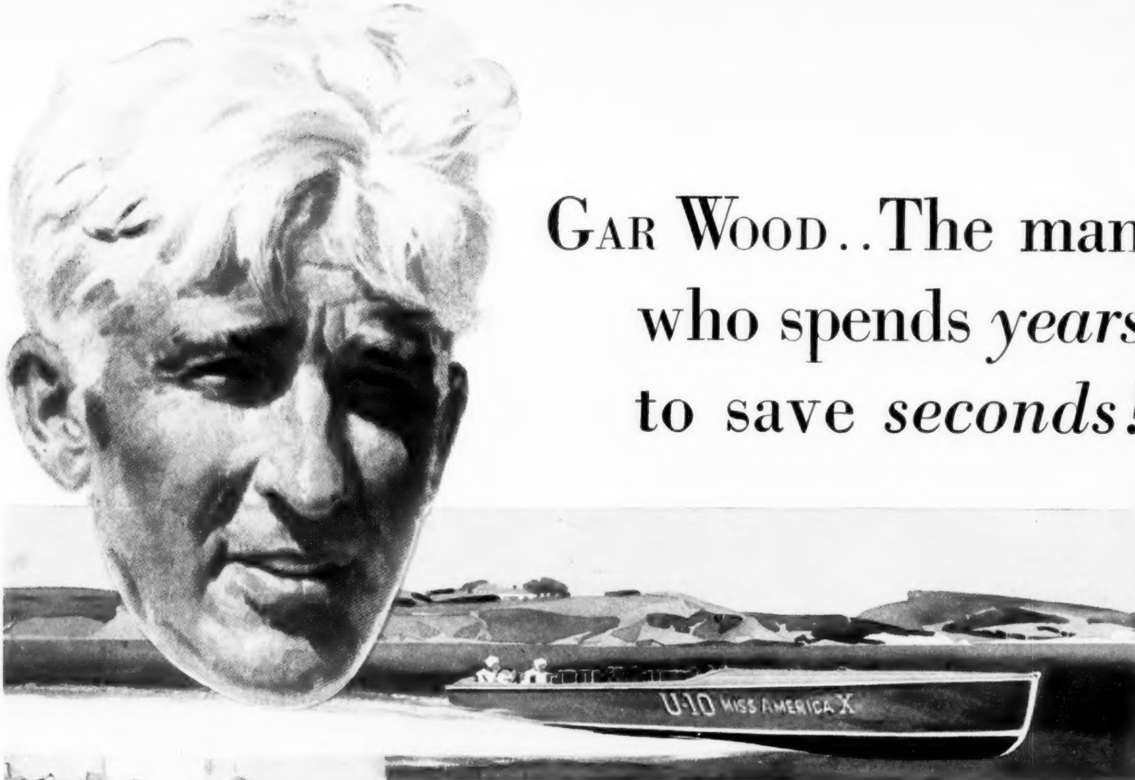
# Gar Wood . . The man who spends *years* to save *seconds!*




*Gar Wood in the workshop of his home at Gray Haven where experiments are continually being carried on.*

*At the boat landing on the Detroit River, Gar Wood looks over some of the boats which have made him world-famous.*

*An amphibian plane and four automobiles help him indulge his hobby for speed. Here is Gar Wood talking with his airplane pilot.*

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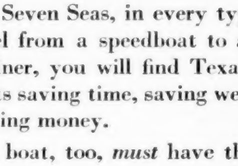


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